APPENDIX C

COMPASS AND PACE SURVEY

The survey will require 1) professional magnetic compass, 2) clinometer, 3) protractor, 4) engineer's scale, 5) calculator with trigonometric functions, and 6) engineer's field notebook with stiff binding and sharp 4-H pencil.

DIRECTION

The compass is used to determine horizontal angles. There are two basic compass types -- one indicates azimuths and the other bearings.

For azimuths, the compass circle is graduated in degrees from 0^{o} to 360^{o} counter clockwise.

For bearings, each quadrant of the compass circle is numbered from 0^{o} to 90^{o} degrees, and a typical bearing is N 30^{o} W.

With both types, the compass circle is lettered and degrees numbered in reverse: east and west are interchanged and the degrees are numbered counter clockwise. This way, north of the graduated compass circle is pointed at a feature, and the compass needle points to the azimuth or bearing which can be read directly from the compass circle.

The compass is held waist high and flat in the left hand with left forearm pressed against the waist. The compass is further steadied with the right hand. The compass needle must be free floating and not bind on the compass case. The compass is correctly sighted when north of the compass circle points to the feature. The north seeking end of the compass needle (usually painted white) then points to the feature's azimuth or bearing on the compass circle. Record this bearing in the field book (sample field notes are shown in Fig. C1) and correct for magnetic north, as follows:

The magnetized compass needle seeks and points toward magnetic north which differs from the geographic north pole by an angle equal to the magnetic declination. Magnetic declination is found in the margin notes of 7.5' topographic maps. Fig. C2 illustrates a typical magnetic declination. Some compasses have the means to adjust the compass circle for local magnetic declination, and geographic north can be read directly. In this case, adjust the compass circle as directed by the compass instruction manual.

If the compass circle cannot be adjusted, geographic north must be calculated from magnetic north and declination.

F-12,13 Compass Survey

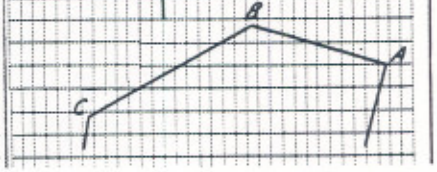
13 JA Jones SSmith BBrown 9

June 11 1940 Rain

Baseball Field Brunton # 43982

Calc. Mag. decl. today taken as 14°30' E of N.

Sta	Dist	Fore Bearing Mag Be	Back Bearing Mag Be	Calc Av Mag Be	Calc Int ∠
A					
	64.8	N86°W	S86°30'E	N86°15'W	
B					175°15'
	135.0	S89°W	N89°E	S89°W	
C					



F-17-18 H Distance with Chain and Level

13 JA Jones SSmith BBrown 18

June 18 1940 Clear, hot

Gully W of Field Level 61, chain 14, rod 8

Calc. H Dist.

Sta	B.S. +	HI	F.S. −	Elev	Slope Dist
A	0.50	770.50		577.0	
					109.00
1	0.75	760.70	10.55	759.95	
					102.00
2	1.25	752.60	9.35	751.35	

℄ Road at culvert

108.3

100.8

℄ Road N end bridge

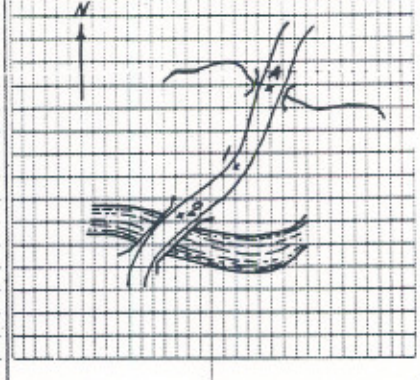


Figure C1. Survey Notes
(Kelly, 1964, p. 181, 184)

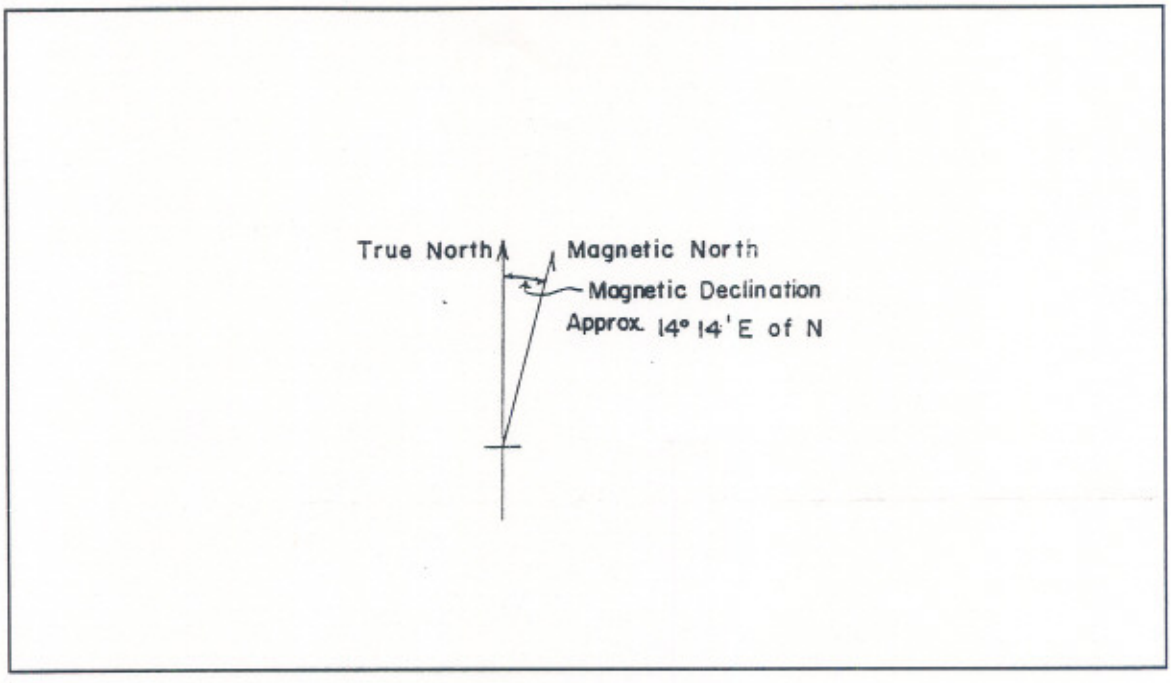


Figure C2. Magnetic Declination
(Kelly, 1964, p. 72)

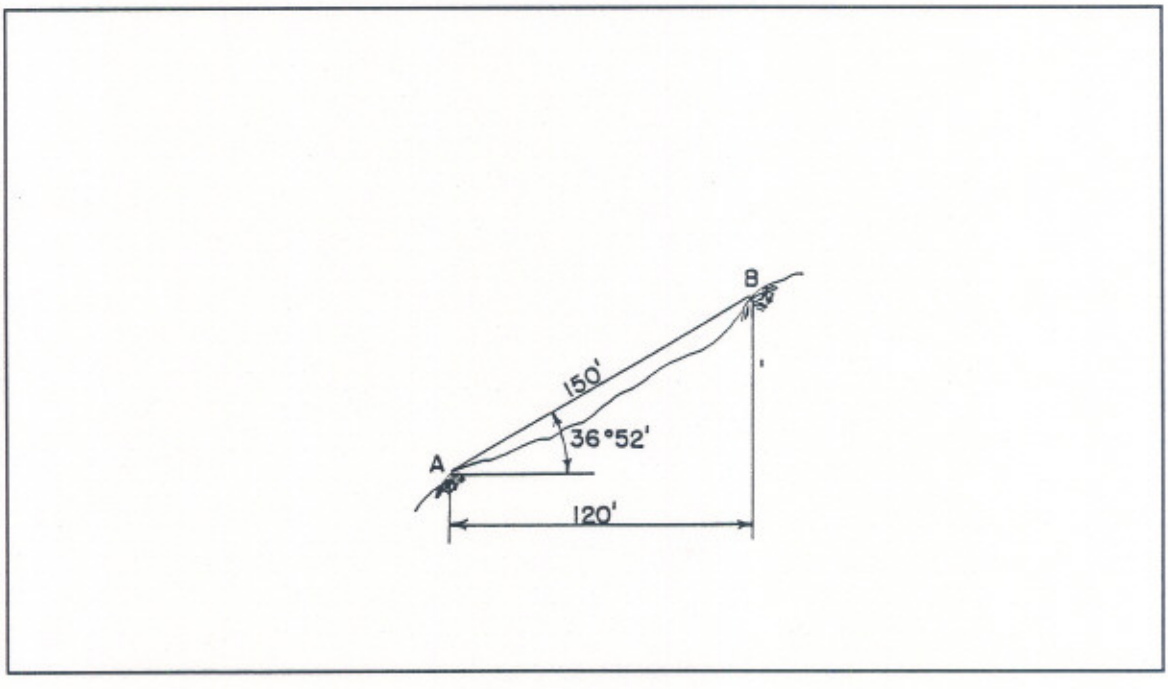


Figure C3. Horizontal Distance
(Kelly, 1964, p. 74)

For azimuths, this calculation is simply an addition or subtraction of the declination angle from the magnetic north reading. Add the declination if magnetic north is east of geographic north, and subtract if magnetic north is west of geographic north.

For bearings, the calculation depends on both the relative position of magnetic and geographic north, and the quadrant. If magnetic north is east of geographic north, add the declination angle to magnetic north in the NE and SW quadrants, and subtract in the NW and SE quadrants.

DISTANCE

Determine the distance between site features by pacing. Count paces between features and convert to ground distance by multiplying paces by your pace length. Beware that pace length is not a consistent quantity. Many things effect pace length such as fatigue, speed at which one walks, slope of the ground, and weather conditions.

Before leaving for the field, pace a known or tape measured distance. Count your steps and time the course. The distance should exceed 100 ft for a reliable average pace length. Divide the distance by the number of paces, and the result is average pace length. Use the course times to control your walking rate. Repeat this procedure several times to obtain an average pace length. In addition repeat the procedure for various types of terrain -- level and steep, up and down hill, etc. Record the results below and use to measure length in the field.

(1) Level Ground: Measured Distance=_____ft

Trial:	1	2	3	4	
Time:	_____	_____	_____	_____	Average=_____.
Paces:	_____	_____	_____	_____	Average=_____.

Unit Pace Length = _____ ft / _____ paces = _____ ft/pace

(2) Up Slope: Measured Distance=_____ft

Trial:	1	2	3	4	
Time:	_____	_____	_____	_____	Average=_____.
Paces:	_____	_____	_____	_____	Average=_____.

Unit Pace Length = _____ ft / _____ paces = _____ ft/pace

(3) Down Slope: Measured Distance=_____ft

Trial:	1	2	3	4	
Time:	_____	_____	_____	_____	Average=_____.
Paces:	_____	_____	_____	_____	Average=_____.

Unit Pace Length = _____ ft / _____ paces = _____ ft/pace

In the preceding trials, do not include suspect values that deviate significantly from the trials.

Slopes must be converted to horizontal distance. First pace the slope, and convert paces to distance with the appropriate unit pace length. Measure the vertical angle (angle of slope) between points. See Fig. C3. Convert slope distance to horizontal distance with the following formula:

Horizontal Distance = Slope Distance x cos(Vertical Angle)

The measured distance must be a relatively constant slope. If there are any significant breaks in the slope, it must be broken into segments that are individually surveyed.

Vertical angles are measured with a clinometer. Alternatively, some professional compasses have built-in clinometers. For measuring vertical angles, follow instructions with clinometer or compass . Because there is such a variety of these tools, here it is not possible to provide any general instructions on their use.

FIELD NOTES

The following instructions should be observed in recording a survey (refer to Fig. C1 for example field notes):

1. Use standard engineers' field notebook with stiff binding.

2. Use 4-H or harder pencil sharpened so as to indent paper.

3. Print all notes and never erase. Make notes permanent, legible, and complete.

4. Record all observed and calculated data immediately. All field calculations should be recorded in the notes.

5. Anticipate questions that may arise concerning interpretation of the notes and arrange notes to be self-explanatory.

6. Good notes have many explanatory remarks and sketches.

7. Set up a Table of Contents before starting the first survey. Column headings should include name of AML site, survey title, date, and page number. Leave enough blank pages for a complete Table of Contents.

8. Number the right hand pages only, in upper right-hand corner.

9. Write AML site and survey title at the top of each left-hand page.

10. Always start a new survey on a new pair of pages.

11. The left-hand page should contain the field data in table form.

12. The right-hand page should include:

    a. Date of survey.
    b. Place of survey.
    c. Name of field notes recorder.
    d. Names of other members of party and their roles.
    e. Weather conditions.
    f. Sketches.
    g. Descriptions.

13. Whole pages in error should be marked "abandoned," and one diagonal line drawn across the page.

TRAVERSE PROCEDURE

Set-up field notes as shown in Fig. C1. Sketch the survey on the left-hand page.

Plan the route of the traverse so that it becomes a polygon, a closed plane figure bounded by three or more line segments. If it is impractical to incorporate all the AML features as vertices in a polygon, add intermediate turning points or break-up the survey into several polygons. Polygons provide a convenient method of quality control.

Start the compass traverse from the reference point selected and mapped in the above Location Block. With the compass, find the direction of the first AML feature or turning point. Record the point and its direction in the field notebook.

Pace the distance to the point, record paces, and convert to distance. Sketch significant objects along or crossing this traverse segment such as buildings, fences, roadways, power lines, waterways, etc.

At each turning point or AML feature in the traverse, measure the forward magnetic bearing to the next point, and, for quality control, the back magnetic bearing to the preceding point. Calculate average bearings of the foresight and backsight except in cases that indicate a magnetic disturbance causing a wide difference between back and forward bearings. In these cases, use as true bearing the value obtained from the sighting not affected by the magnetic disturbance.

From the average bearings of adjacent lines calculate the interior angles between lines. Fig. C4 illustrates the conversion of bearings or azimuths to interior angles.

Repeat the distance and bearing measurements to each of the AML features and intermediate turning points. Finally, close the survey by returning to the reference point or beginning point.

QUALITY CONTROL

For a quick check, total the interior angles which should approximate 360^{o}. In the field notes, indicate the total error and the average error per angle. If the average error is more than 3^{o}. look for calculation errors and/or repeat the traverse. If the average error is acceptable, adjust each angle by the average error.

For a more thorough check, use the method of balancing latitudes and departures. The method is illustrated in Fig. C5. The upper half of the figure illustrates the definitions of latitudes and departures.

Latitude is the projection of a given course on a north-south line. It is taken as positive towards the north.

Latitude = Length x cos(Bearing Angle)

Departure is the projection of a given course on an east-west line. It is taken as positive towards the east.

Departure = Length x sin(Bearing Angle)

The algebraic total of latitudes, and the algebraic total of departures in a closed traverse should equal zero. However, it is impossible to run a survey with sufficient accuracy to accomplish this condition. If the error of closure, that is the difference between the algebraic total and zero in latitudes or departures, is relatively small or less than 3%, the traverse is balanced so that the totals do come out to zero. First, the angles must be balance as described above. Then adjust the latitudes and departures with the following formula:

$$\text{Segment Error (Lat or Dep)} = \text{Total Error} \times \frac{\text{Segment Length}}{\text{Total Traverse Length}}$$

After this adjustment, calculate the adjusted segment length by solving either of the above latitude or departure formulas, as follows:

Length = Adjusted Latitude / cos(Bearing Angle) or

Length = Adjusted Departure / sin(Bearing Angle)

If the total error is unacceptable, check for computation errors and/or repeat the traverse.

REFERENCE: Kelly, T.A., Plane Surveying Field Manual, Colorado School of Mines, Golden CO, 1964, 229 p.

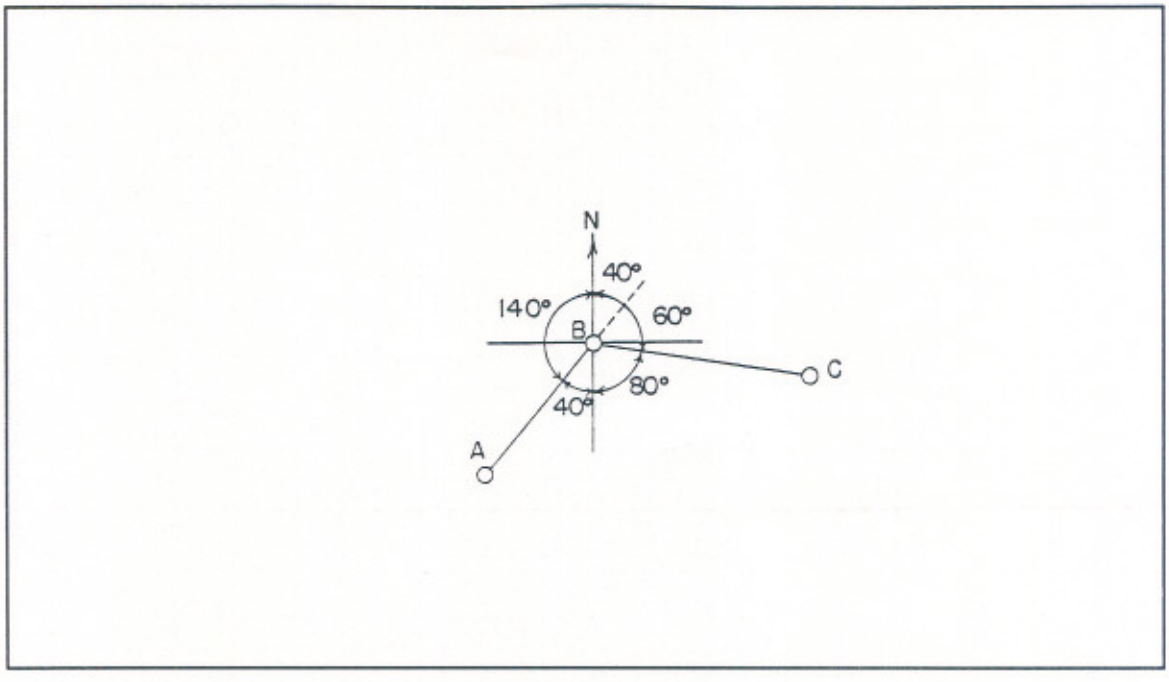
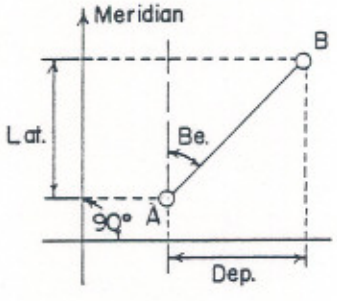


Figure C4.
(Kelly, 1964, p. 81)



Line	Length	Bearing	Lat		Dep.		Bal. Lat.		Bal. Dep.	
			+ N	− S	+E	− W	+ N	− S	+E	- W
AB	202.0′	N 15°26′ E	194.7′		53.6′		194.2′		53.3′	
BC	564.0′	S 47°19′ E		382.4′	414.6′			383.7′	414.2′	
CD	504.0′	N 67°46′W	190.7′			466.5′	189.5′			467.2′
Total			385.4′	382.4′	468.2′	466.5′	383.7′	383.7′	467.5′	467.2′

Figure C5.
(Kelly, 1964, p. 93)